

**AN ANALYSIS OF MORTALITY, MORBIDITY, AND PRIMARY CARE PROVIDERS
IN ARIZONA'S 126 PRIMARY CARE AREAS**

A thesis submitted to the University of Arizona College of Medicine – Phoenix
in partial fulfillment of the requirements for the Degree of Doctor of Medicine

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Dedication

To my family for their unconditional love and support; especially to my dad, Dr. Paul Wassermann, for demonstrating what it means to be the consummate physician and father.

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I wish to thank my mentor Dr. Jonathan Cartsonis for his guidance and tireless commitment to furthering his students' education. Additionally, this project would not be possible without Paul Kang's statistical analyses.

Abstract

Research questions: Is there any association between the total number of primary care providers and mortality per 100,000 persons (all deaths, heart disease, all cancer, chronic lower respiratory disease, and all accidents), or morbidity per 100,000 persons (chronic diseases, congestive heart failure, hypertension, uncontrolled diabetes, and stroke)? Is there any difference in total number of primary care providers, mortality per 100,000 persons, or morbidity per 100,000 persons in rural vs urban primary care areas?

Background: The United States is currently facing a primary care provider shortage. Medical schools nationwide have increased enrollment in order offset the effects of the shortage. In order to justify the effects of increasing total quantity of future physicians, there should be a demonstrated relationship between total quantity of providers and a reduction in morbidity / mortality at a population health level.

Methods: Data was gathered from the Arizona Department of Health Services community profiles dashboard. 2013 morbidity / mortality data for all 126 of Arizona's Primary Care Areas was analyzed utilizing linear regression and Wilcoxon rank sum.

Results: Linear regression demonstrated a statistically significant reduction in a number of mortality / morbidity categories as total number of primary care providers increased.

Correlation data demonstrated a statistically significant relationship between number of primary care providers and increase in chronic lower respiratory diseases (p value = 0.027).

Additionally, rural primary care areas showed higher incidence of congestive heart failure ($p < 0.001$) and chronic diseases ($p = 0.02$) and lower total numbers of primary care providers ($p < 0.001$) compared with urban primary care areas.

Conclusions and Impact: Our findings demonstrate distinct differences between urban and rural primary care areas. There may be some association between total number of primary care providers and their potential effect on mortality/morbidity incidence. Further research needs to be completed in order to elucidate a greater understanding of these potential relationships.

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Introduction / Significance

According to a report published in 2013 by the Association of American Medical Colleges (AAMC), Arizona ranked 43rd in the nation for its shortage of primary care physicians. In response to the perceived impending physician, medical schools nationwide have lobbied to increase their enrollment capacities in an effort to offset the potential adverse effects of the shortage despite the fact that graduate medical education residency spots have remained relatively stagnant since the mid-1990s.

What remains to be seen is whether or not new graduates that pursue primary care practice will do so in a rural setting. Rural environments are fundamentally unique in their composition and access to healthcare resources. These areas have felt the burden of the primary care provider shortage greatly and will continue to do so unless these areas continue to attract PCPs. In order to demonstrate the importance of rural primary care providers, their necessity must be clearly demonstrated.

Additionally, in order to justify the need to substantially increase the overall number of physicians, state officials should be able to clearly demonstrate that regional health areas with low primary care providers to patient ratios have a higher rate of all cause mortality and morbidity. Our research project aims to explore the relationship between all-cause mortality/morbidity and primary care physician delineated by primary care areas as defined by the Arizona Department of Health Services utilizing data from 2013.

Materials and Methods

2013 public health data were made available from the Arizona Department of Health Services (AzDHS) community profiles dashboard. Individual community profile data for 126 out of 126 of Arizona's Primary Care Areas (PCAs) were then extracted and obtained for the following fields: total number of primary care providers, mortality per 100,000 (all deaths, heart disease, all cancer, chronic lower respiratory disease, all accidents), and morbidity per 100,000 (stroke, chronic diseases, congestive heart failure, hypertension, uncontrolled diabetes). Additionally, utilizing the AzDHS community profiles dashboard, we further compared the following variables for "rural" vs "urban" PCAs: total number of primary care providers, mortality per 100,000 (all deaths, heart disease, all cancer, chronic lower respiratory disease, all accidents), and morbidity per 100,000 (stroke, chronic diseases, congestive heart failure, hypertension, uncontrolled diabetes).

For the purpose of univariate linear regression analysis, data was separated into quartiles. Wilcoxon rank sum was utilized to compare total number of primary care providers, mortality, and morbidity in 41 rural vs 65 urban PCAs.

Results

Our results demonstrate the following findings:

Research Question 1:

When total number of primary care providers was divided into quartiles of 0-15, 15-46, 46-147, and >147 primary care providers, the following Mortality findings were shown when using the first quartile as the Reference control:

- As primary care providers increased, there was a statistically significant decrease in All Deaths per 100,000 individuals in second, third, and fourth quartiles (p values 0.002, 0.003, and 0.01 respectively).
- As primary care providers increased, there was a statistically significant decrease in deaths from Heart Disease per 100,000 individuals in second, third, and fourth quartiles (p values 0.007, 0.007, and 0.03 respectively).
- As primary care providers increased, there was a statistically significant decrease in deaths from All Accidents per 100,000 individuals in second, third, and fourth quartiles (p values 0.02, 0.009, and 0.009 respectively).
- There was a statistically significant decrease in the second quartile for deaths from All Cancer per 100,000 individuals (p value 0.02), but the third and fourth quartiles did not demonstrate a statistically significant relationship (p values 0.07 and 0.07 respectively).
- There was no statistically significant relationship between total primary care providers and deaths from Chronic Respiratory Disease per 100,000 individuals (p values > 0.05).

The following Morbidity findings were shown:

- As primary care providers increased, there was a statistically significant decrease Uncontrolled Diabetes per 100,000 individuals in the third and fourth quartiles (p values 0.04 and 0.04, respectively) and approached statistical significance in the second quartile (p value 0.08).
- There was a statistically significant decrease in Chronic Disease incidence per 100,000 individuals in the second and third quartiles (p values 0.02 and 0.01), but not the fourth quartile (p value 0.05).
- There was a statistically significant decrease in Congestive Heart Failure incidence per 100,000 individuals in the third quartile (p values 0.04) and approached statistical significance in the fourth quartile (p value 0.08), but not the second quartile (p value > 0.05).
- There was no statistically significant relationship between an increase in primary care providers and Stroke or Hypertension per 100,000 individuals (p values > 0.05).

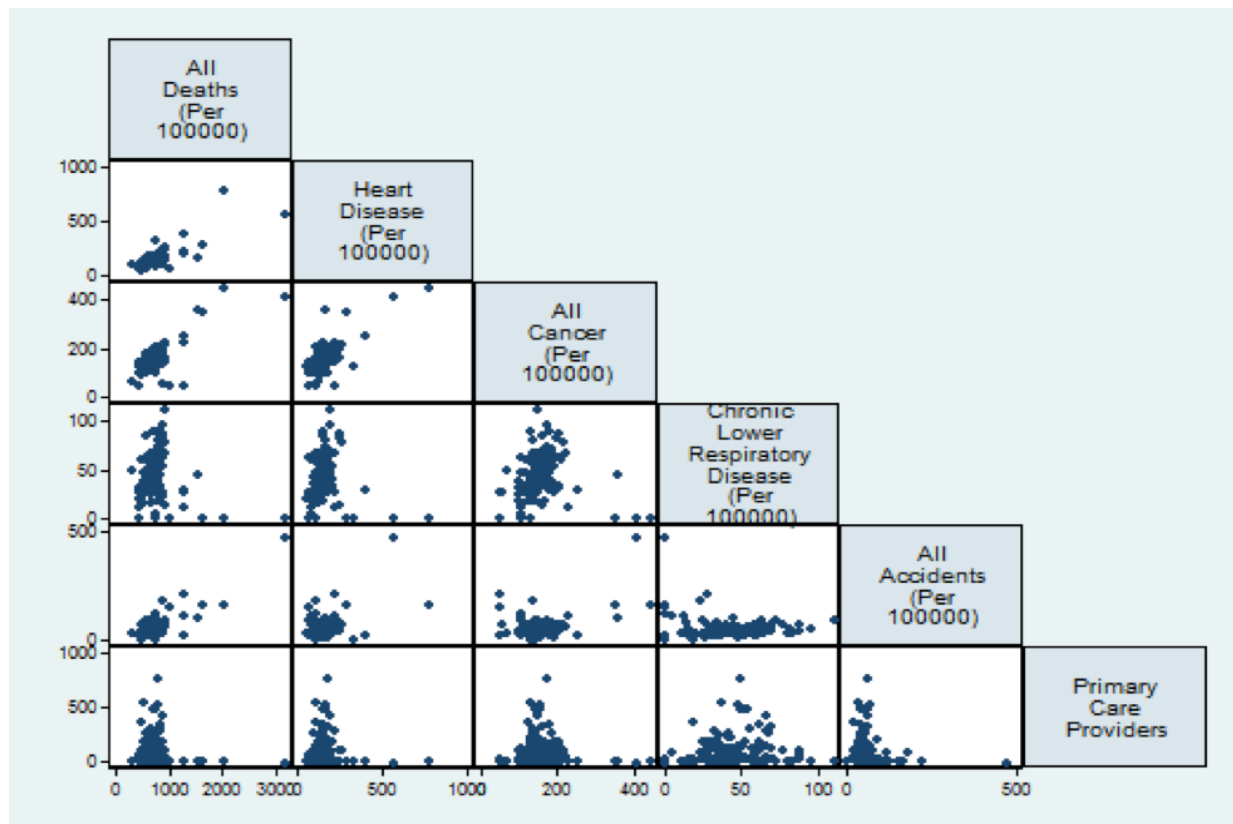
Research Question 2

Our results demonstrate the following findings in Table 3:

- There is a statistically significant difference in the total number of primary care providers in rural vs urban primary care areas with rural primary care areas having fewer physicians than their urban counterparts (p value < 0.001).
- Additionally, there is a higher rate of congestive heart failure and chronic disease per 100,000 individuals in rural primary care areas (p values < 0.001 and 0.002 respectively).
- There was no statistically significant relationship in all remaining mortality and morbidity categories (p values > 0.05).

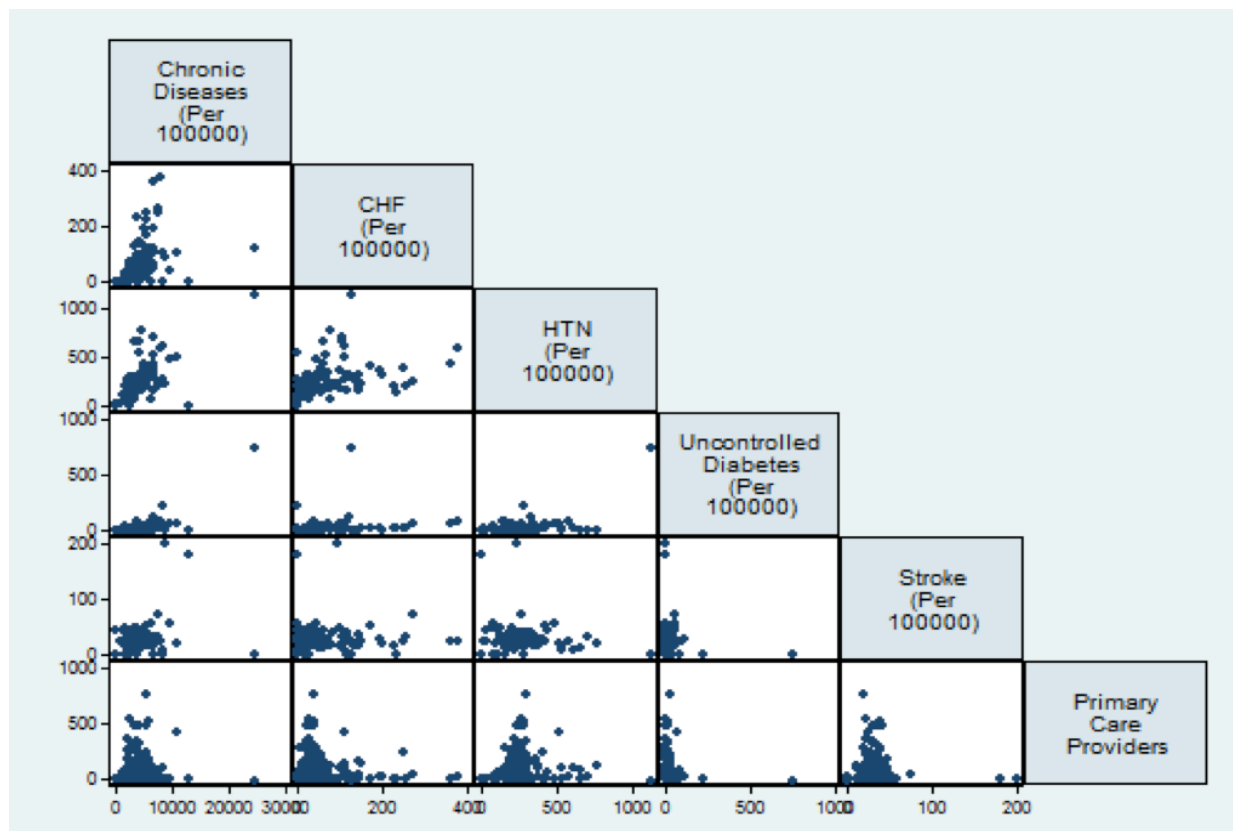
Variables	Values
Primary Care Physicians (mean, SD)	106.4 (136.6)
<u>Mortality per 100,000 (mean, SD)</u>	
All deaths	751.1 (313.2)
Heart Disease	156.9 (83.2)
All Cancer	157.7 (55.7)
Chronic Respiratory Disease	42.8 (21.8)
All Accidents	56.2 (50.3)
Stroke	29.9 (24.1)
<u>Morbidity per 100000 (mean, SD)</u>	
Chronic Disease	4405.7 (2747.5)
Congestive Heart Failure	61.1 (69.4)
Hypertension	272.9 (154.5)
Uncontrolled Diabetes	27.1 (70.9)

Table 4. Mean Values for Primary Care Providers, Morbidity and Mortality in 126 Primary Care Areas in Arizona in 2013.



	All Deaths (Per 100000)	Heart Disease (Per 100000)	All Cancer (Per 100000)	Chronic Lower Respiratory Disease (Per 100000)	All Accidents (Per 100000)
Number of PCPs	-0.0717	-0.0412	-0.0054	0.1970	-0.1469
	0.4250	0.6473	0.9526	0.0271	0.1007

Figure 5. Correlation matrix between number of primary care providers and incidence of mortality from all deaths, heart disease, all cancer, chronic lower respiratory disease, and all accidents per 100,000 individuals in Arizona in 2013. Correlation coefficients listed at the bottom of the figure.



	Chronic Diseases	CHF	All Cancer	HTN	Stroke
Number of PCPs	-0.0820	-0.0980	0.1440	-0.0881	0.1632
	0.3615	0.2747	0.1077	0.3266	0.0679

Figure 6. Correlation matrix between number of primary care providers and incidence of morbidity from chronic diseases, congestive heart failure, hypertension (HTN), uncontrolled diabetes, and stroke per 100,000 individuals in Arizona in 2013. Correlation coefficients listed at the bottom of the figure.

Outcomes	Number of PCP's < 15 (n=32)	>15 - < 46 (n=31)	>46 - < 147 (n=32)	>147 (n=31)
Mortality per 100,000 (mean, SD)				
All deaths	915.8 (549.6)	680.8 (171.7)	688.2 (120.4)	716.3 (111.9)
Coef (95% CI)	REF	-234.9 (-385.2, -84.6)	-227.5 (-376.6, -78.4)	-199.5 (-349.8, -49.2)
P-value ¹		0.002	0.003	0.01
Heart Disease	196.2 (146.2)	139.9 (41.4)	140.3 (43.1)	150.5 (29.5)
Coef (95% CI)	REF	-56.3 (-96.7, -15.9)	-55.9 (-95.9, -15.9)	-45.8 (-86.1, -5.41)
P-value ¹		0.007	0.007	0.03
All Cancer	178.7 (94.5)	145.3 (41.3)	152.9 (28.3)	153.5 (22.5)
Coef (95% CI)	REF	-33.4 (-60.8, -5.97)	-25.8 (-53.0, 1.35)	-25.2 (-52.6, 2.21)
P-value ¹		0.02	0.07	0.07
Chronic Respiratory Disease	38.8 (29.7)	40.4 (22.1)	46.2 (18.7)	45.6 (13.9)
Coef (95% CI)	REF	1.62 (-9.31, 12.6)	7.35 (-3.49, 18.2)	6.82 (-4.11, 17.8)
P-value ¹		0.76	0.18	0.22
All Accidents	79.9 (82.8)	50.0 (38.3)	47.4 (31.2)	47.0 (13.4)
Coef (95% CI)	REF	-29.9 (-54.3, -5.55)	-32.5 (-56.7, -8.35)	-32.9 (-57.3, -8.56)
P-value ¹		0.02	0.009	0.009
Morbidity per 100,000 (mean, SD)				
Stroke	33.7 (44.5)	27.0 (13.1)	28.8 (10.7)	30.2 (7.46)
Coef (95% CI)	REF	-6.68 (-18.8, 5.41)	-4.91 (-16.9, 7.08)	-3.47 (-15.6, 8.62)
P-value ¹		0.28	0.42	0.57
Chronic Disease	5572.2 (4366.5)	3974.9 (1926.9)	3826.6 (1668.0)	4233.2 (1769.2)
Coef (95% CI)	REF	-1600.2 (-2942.0, -258.4)	-1745.6 (-3076.7, -414.5)	-1338.9 (-2680.8, 2.82)
P-value ¹		0.02	0.01	0.05
Congestive Heart Failure	77.5 (88.6)	77.9 (84.2)	42.6 (33.9)	46.6 (50.4)
Coef (95% CI)	REF	0.49 (-33.5, 34.5)	-34.8 (-68.6, -1.10)	-30.8 (-64.9, 3.19)
P-value ¹		0.97	0.04	0.08
Hypertension	266.3 (222.6)	266.3 (130.8)	289.1 (158.1)	269.8 (69.9)
Coef (95% CI)	REF	-0.001 (-77.9, 77.8)	22.9 (-54.4, 100.1)	3.53 (-74.3, 81.4)
P-value ¹		>0.99	0.56	0.92
Uncontrolled Diabetes	53.1 (134.7)	21.8 (27.0)	16.2 (17.5)	16.7 (13.7)
Coef (95% CI)	REF	-31.4 (-66.3, 3.61)	-36.9 (-71.7, -2.28)	-36.5 (-71.4, -1.51)
P-value ¹		0.08	0.04	0.04

¹Coef (95% CI) calculated using Univariate linear regression.

Table 5. Univariate linear regression comparing total number of primary care providers to mortality and morbidity per 100,000 persons.

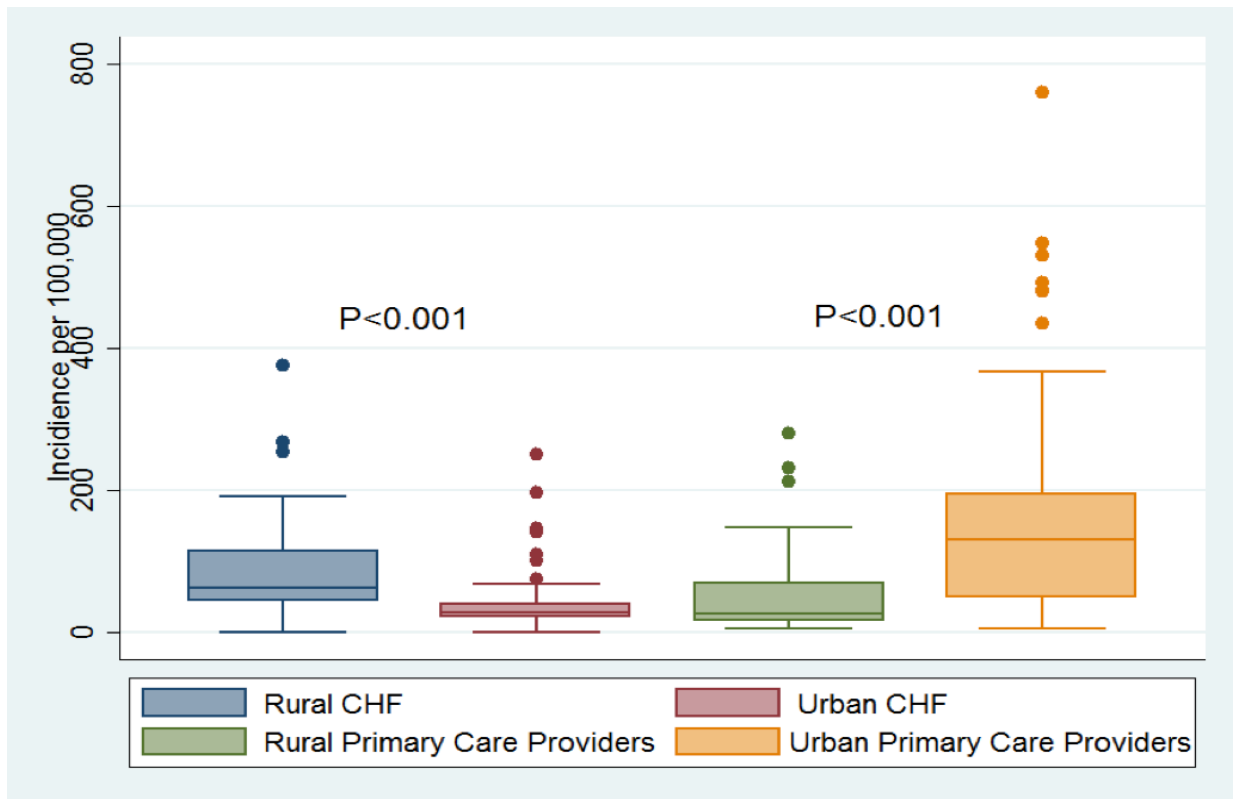


Figure 7. Comparison of the incidence of congestive heart failure (CHF) cases per 100,000 individuals in rural vs urban primary care areas and the total number of primary care providers, per 100,000 in rural vs urban primary care areas in Arizona in 2013. Mean number of rural CHF cases is 86.77 per 100,000 individuals (standard deviation is +/- 76.2) and mean number of urban CHF cases is 41.13 per 100,000 (standard deviation is +/- 43.48), p value < 0.001. Mean number of rural primary care providers is 54.88 (standard deviation is +/- 64.61) and mean number of urban primary care providers 167.80 (standard deviation is +/- 159.67), p value < 0.001.

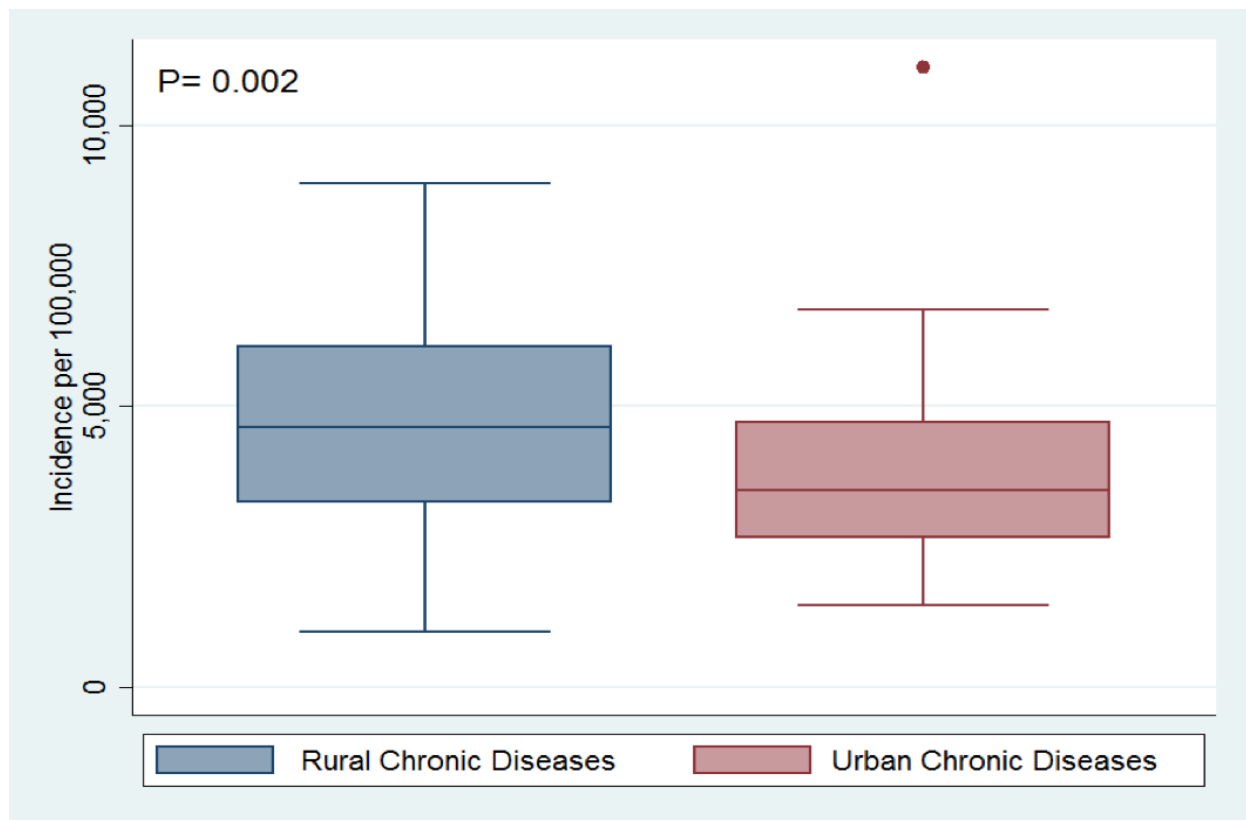


Figure 8. Comparison of the incidence of chronic diseases per 100,000 individuals in rural vs urban primary care areas in Arizona in 2013. Mean number of rural chronic disease incidence is 4824.64 per 100,000 individuals (standard deviation is +/- 1892.17) and mean number of urban chronic disease incidence is 3730.23 per 100,000 individuals (standard deviation is +/- 1575.76), p value 0.002.

Variables	Rural Mean (Std Deviation)	Urban Mean (Std Deviation)	P-value ¹
Primary care Physicians	54.88 ± (64.61)	167.80 ± (159.67)	<0.001
All Deaths	708.32 ± (161.39)	696.12 ± (124.53)	0.91
Heart Disease	155.70 ± (59.14)	142.90 ± (31.34)	0.56
All Cancer	159.71 ± (35.34)	153.64 ± (25.15)	0.49
Chronic Respiratory	47.69 ± (23.53)	45.37 ± (17.19)	0.81
All Accident	47.95 ± (20.77)	44.92 ± (22.77)	0.45
Stroke	33.27 ± (29.56)	28.76 ± (8.61)	0.68
Chronic Disease	4824.68 ± (1892.17)	3730.23 ± (1575.76)	0.002
CHF	86.77 ± (76.72)	41.13 ± (43.48)	<0.001
Hypertension	284.57 ± (133.56)	280.62 ± (117.97)	0.86
Uncontrolled Diabetes	23.04 ± (25.28)	15.33 ± (14.24)	0.14

¹Wilcoxon Rank Sum used to compare continuous variables.

Table 6. Wilcoxon rank sum analysis between rural and urban PCAs evaluating total number of primary care providers, mortality per 100,000 persons (all deaths, heart disease, all cancer, chronic lower respiratory disease, all accidents), and morbidity per 100,000 persons (stroke, chronic disease, congestive heart failure (CHF), hypertension, and uncontrolled diabetes).

Discussion – Research Question 1

Research Question 1: Is there any association between the total number of primary care providers and mortality per 100,000 persons (all deaths, heart disease, all cancer, chronic lower respiratory disease, and all accidents), or morbidity per 100,000 persons (chronic diseases, congestive heart failure, hypertension, uncontrolled diabetes, and stroke)?

Discussion: Through univariate linear regression analysis comparing total number of primary care providers to mortality categories per 100,000 persons, our findings demonstrate statistical significance with a negative linear correlation in the following categories: all deaths, heart disease, and all accidents when quantified into four quadrants. As the number of primary care providers increased, these categories saw a reduction in incidence of mortality per 100,000. There was a slight reduction in all deaths from cancer with total number of primary care providers in the 15 to 46 range, but no statistically significant reduction in mortality past this range. There was no statistically significant relationship between total number of primary care providers and deaths from chronic lower respiratory disease.

Additionally, through univariate linear regression analysis comparing total number of primary care providers to morbidity categories per 100,000 persons our findings demonstrate statistical significance with a negative linear correlation in the following category: chronic diseases and uncontrolled diabetes. As the number of primary care providers increased, there was a total reduction across all provider quadrants. Morbidity per 100,000 persons approached statistical significance in the category of congestive heart failure.

Discussion – Research Question 2

Research Question 2: Is there any difference in total number of primary care providers, mortality per 100,000 persons, or morbidity per 100,000 persons in rural vs urban primary care areas?

Discussion: Wilcoxon rank sum demonstrated a statistically significant difference between total number of primary care providers, congestive heart failure, and chronic diseases in rural vs urban primary care areas. Urban primary care areas had a greater total number of primary care providers and rural areas showed higher rates of congestive heart failure and chronic diseases per 100,000 persons.

Limitations: First and foremost, correlation does not equal causation. While our analyses demonstrate statistical significance in a few categories, there are a number of confounding factors that would prove a relationship exists when in fact there may not be one. Additionally, Data was only available from 2013 and future investigations will need a more robust, longitudinal data set to analyze.

Future Directions

Our data set was relatively small in sample as we were only able to obtain data from 2013. Future investigations will need to compare multiple years of data across all PCAs in order to expound upon our initial findings. Additionally, as we were only able to obtain aggregate data from AzDHS we were not able to determine the compositional makeup of the data collected, specifically, we did not have access to demographic characteristics of the individuals profiled, i.e. age, race, and sex. Given this limitation we were unable to stratify the data to eliminate potential confounders. Future studies should take this into account and control for these characteristics.

We are hopeful that our project demonstrates the continued importance of primary care physicians and their influence on their regional populations. We especially hope to highlight the importance of the rural primary care physician, as we are confident in the distinct socio-ethnographic differences between rural and urban areas. Primary care physicians are desperately needed in these resource-limited areas and their continued importance cannot be understated.

Conclusions

There is a statistically significant relationship in the reduction of certain causes of mortality per 100,000 persons as the total number of primary care providers increases. Additionally, there are a greater number of primary care providers in urban primary care areas, and there is a higher incidence of congestive heart failure and chronic diseases per 100,000 persons in rural primary care areas.

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